

## Pseudosection and thermobarometry constraints on the P-T-t evolution of Ribeira Belt, SE Brazil

J. MUNHÁ<sup>1</sup>, T. BENTO DOS SANTOS<sup>1\*</sup>, C. TASSINARI<sup>2</sup>  
AND P. FONSECA<sup>1</sup>

<sup>1</sup>Centro/Departamento de Geologia, Universidade de Lisboa, Portugal (\*correspondence: tmsantos@fc.ul.pt)

<sup>2</sup>Instituto de Geociências, Universidade de São Paulo, Brazil

Pseudosection analysis, combined with geothermobarometric data and petrographic observations of gneissic migmatites and granulites from the central area of Neoproterozoic Ribeira Belt, SE Brazil is used here in order to quantify the tectonometamorphic P-T evolution during prograde and retrograde metamorphism of the Brazilian Orogeny.

Results establish a prograde metamorphic trajectory from amphibolitic to metamorphic peak granulite facies at  $T=850\pm 50^{\circ}\text{C}$  and  $P=8\pm 1\text{ kbar}$ , consistent with 30 to 40% dehydration-melting (involving significant melt loss) of the gneissic protoliths. After reaching peak metamorphic conditions, migmatites underwent cooling and decompression ( $\Delta T=-200$  to  $-350^{\circ}\text{C}$  and  $\Delta P=-2$  to  $-2.5\text{ kbar}$ ) to  $T\sim 500^{\circ}\text{C}$  and  $P\sim 5\text{ kbar}$ ; the retrograde P-T path was associated with water influx (increasing  $a_{\text{H}_2\text{O}}$ ), with replacement of the high grade garnet-plagioclase-K-feldspar paragenesis by biotite-quartz-sillimanite-muscovite.

Regional high grade conditions were sustained from  $\sim 570$  to  $\sim 480\text{ Ma}$  [1]. The intrinsic long-term high-heat flux induced further dehydration and ( $\sim 10\%$ ) biotite-amphibole-garnet bearing, restite, re-melting at deeper crustal levels, giving rise to widespread development of granulites and associated aplitic intrusions. Thus, granulites can be envisaged as lower crust highly dehydrated restites. During this period, granulites were slowly (nearly isobarically) cooled with  $\Delta T=-100$  to  $-340^{\circ}\text{C}$  and  $\Delta P=-0.1$  to  $-1.8\text{ kbar}$ ; this tectonothermal regime ceased with the tectonic collapse of the orogenic belt, when granulites were rapidly cooled and decompressed ( $\Delta T=-100$  to  $-200^{\circ}\text{C}$  and  $\Delta P=-1$  to  $-3\text{ kbar}$ ) during exhumation ( $\sim 470\text{ Ma}$ ). Retrograde P-T evolution and hydration, induced replacement of early plagioclase-hypersthene-garnet granulite assemblages by biotite-k-feldspar-quartz simplexes, being consistent with a general P-T-t metamorphic path that comprised initial (long-term) isobaric cooling followed by decompression and cooling.

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[1] Bento dos Santos *et al.* (2007) *Geochimica et Cosmochimica Acta* **71**(15) Sup. 1, A79.

## Formation of the lunar magma ocean constrained from high field strength element systematics in lunar rocks

CARSTEN MÜNKER<sup>1,2</sup>

<sup>1</sup>Universität Bonn, Germany (muenker@uni-bonn.de)

<sup>2</sup>Universität Münster, Germany

The compositional diversity of lunar rocks is commonly explained by melting of cumulate layers formed during crystallisation of a lunar magma ocean. Whereas lunar highland rocks and KREEP basalts originate from a trace element enriched layer, lunar mare basalts are inferred to tap trace element depleted cumulate layers. The petrogenesis of high-Ti mare basalts involves either direct melting of, or, alternatively, assimilation of ilmenite-rich cumulate layers by depleted melts. HFSE ratios in lunar rocks, determined by high-precision measurements ([1] and new data) employing isotope dilution, confirm this model in that highland rocks display Nb/Ta and Zr/Hf above the bulk lunar value (ca. 17), whereas mare basalts display lower ratios. Notably, high-Ti mare basalts display lower Nb/Ta and Zr/Hf than low-Ti basalts, consistent with an ilmenite assimilation model. Melting of ilmenite- and clinopyroxene-rich cumulates could not explain this pattern, as ilmenite exhibits similarly low DNb/DTa (ca. 0.6-0.7, [2]) as clinopyroxene (ca. 0.3-0.4). Combined modelling of W abundances with those of other HFSEs provides additional evidence that high-Ti mare basalts are hybrid melts formed by the interaction of low-Ti basaltic melts with ilmenite- and clinopyroxene-rich cumulate layers. Assimilation of such ilmenite-rich layers is also a viable mechanism capable of buffering the Lu/Hf ratios of mare basalts at relatively low values, thus partially explaining the dichotomy between low Lu/Hf ratios in the magmas and high time integrated source Lu/Hf ratios that were previously inferred from Hf isotope compositions.

[1] Münker *et al.* (2003) *Science* **301**, 84-87. [2] Klemme S. *et al.* (2006) *Chem Geol.* **234**, 251-263.